

# Potential Paths for Male-mediated Gene Flow between the NCDE and GYE Grizzly Bear Populations



Christopher Peck, Frank T. van Manen, Cecily Costello, Mark  
Haroldson, Lisa Landenburger, Lori Roberts, Daniel Bjornlie,  
and Richard Mace

*Photo: Jake Davis*



# Acknowledgments

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Blackfeet Nation

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U.S. Fish and Wildlife Service

Wind River Fish and Game-Eastern Shoshone & Northern Arapaho Tribes

Wyoming Game and Fish Department

Chris Servheen, Justin Gude, Robert Inman, Dave Gustine



# Overview

- Background
- Approach
- From science to management





A map of North America showing the distribution of Grizzly and Brown bears. The range is highlighted in yellow and orange, covering most of Canada and parts of the western United States and northern Mexico. The background is a topographic map with brown for land and blue for water. The text "Grizzly/Brown Bear Range" is overlaid in white on the left side.

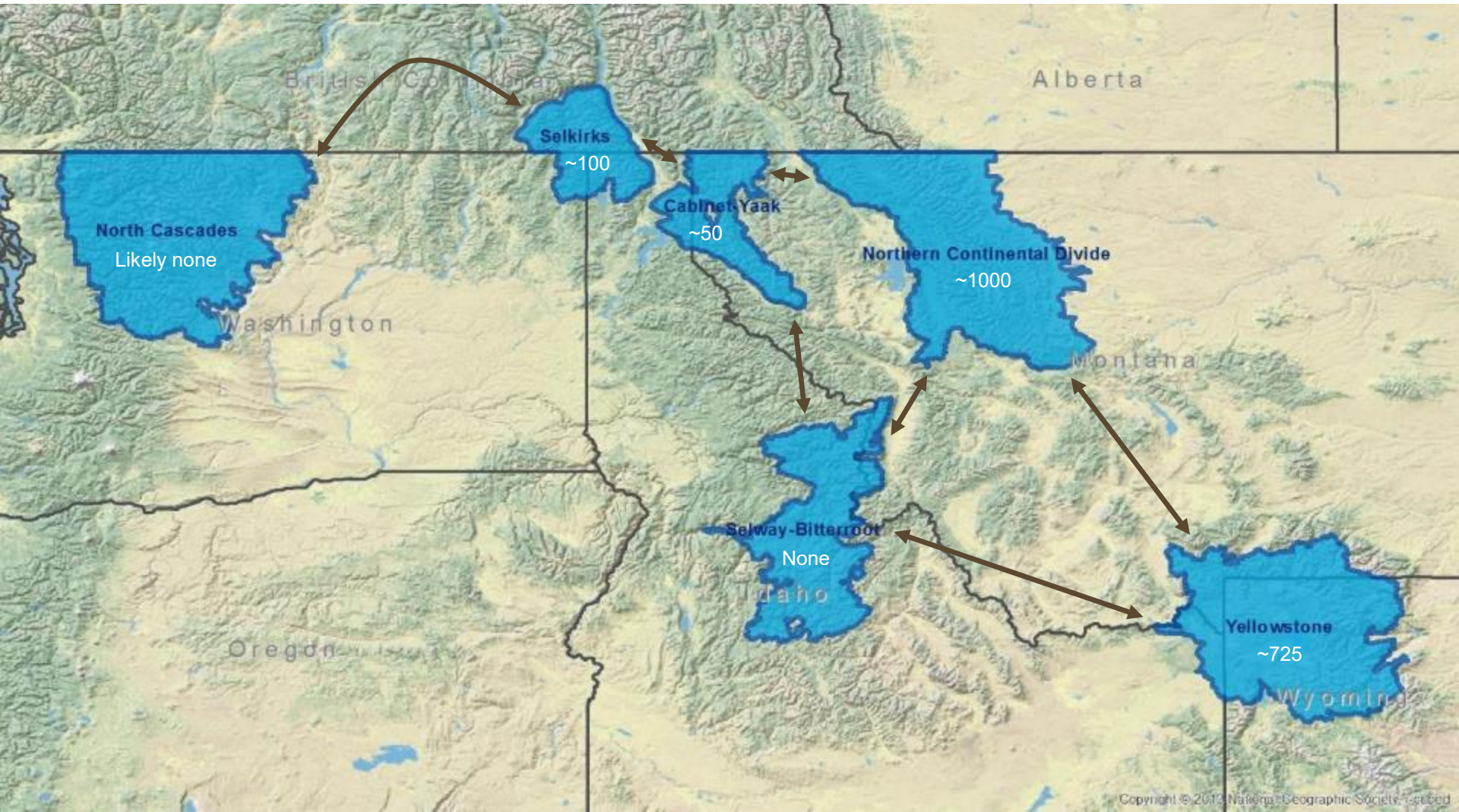
**Grizzly/Brown Bear Range**

**North America**



# Federal Recovery Zones

- Established in Recovery Plans (1982, 1993)





# Federal Recovery Zones

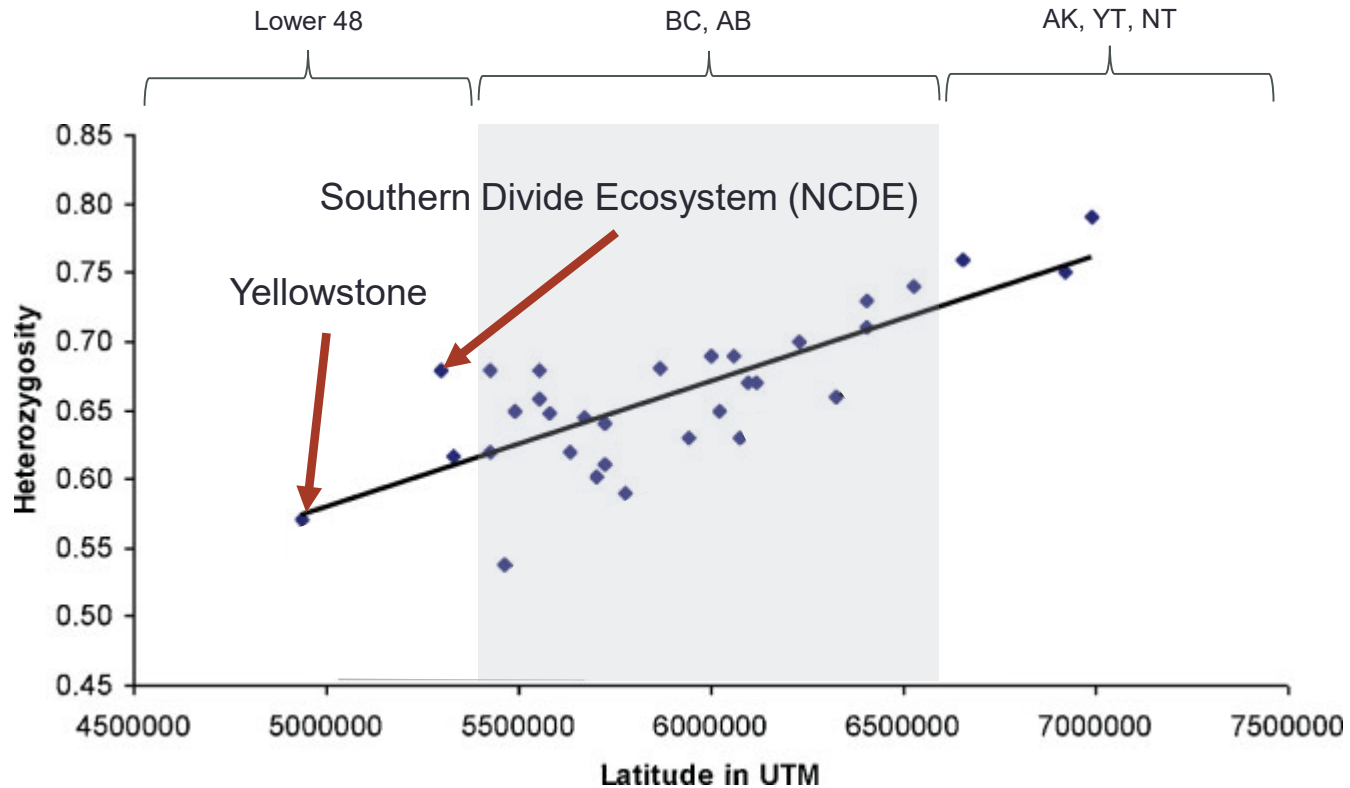
- Established in Recovery Plans (1982, 1993)



# Information need

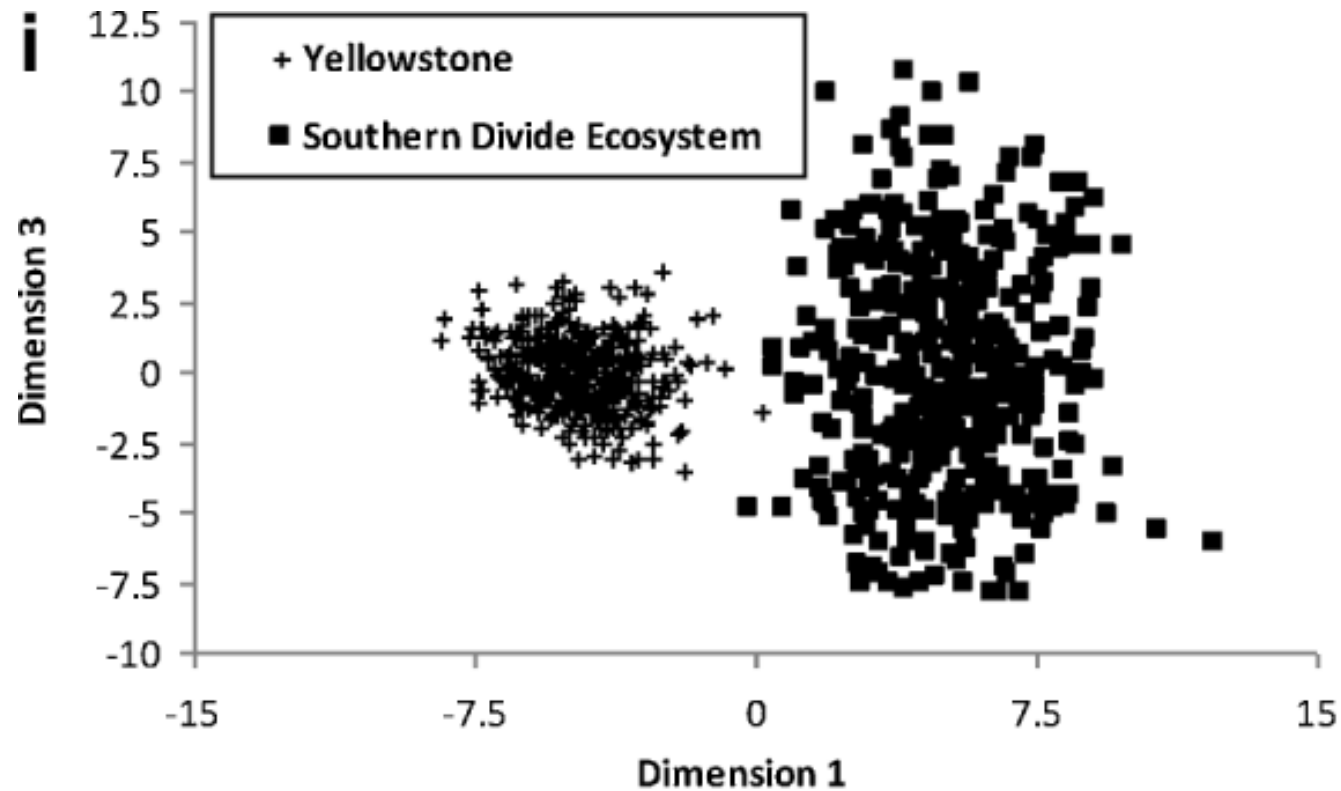
- Identify paths between NCDE and GYE with habitat conditions conducive to male dispersal
- Make predictions based on grizzly bear location data and observed habitat selection
- Explore trade-off between optimal and exploratory paths

# Genetic diversity

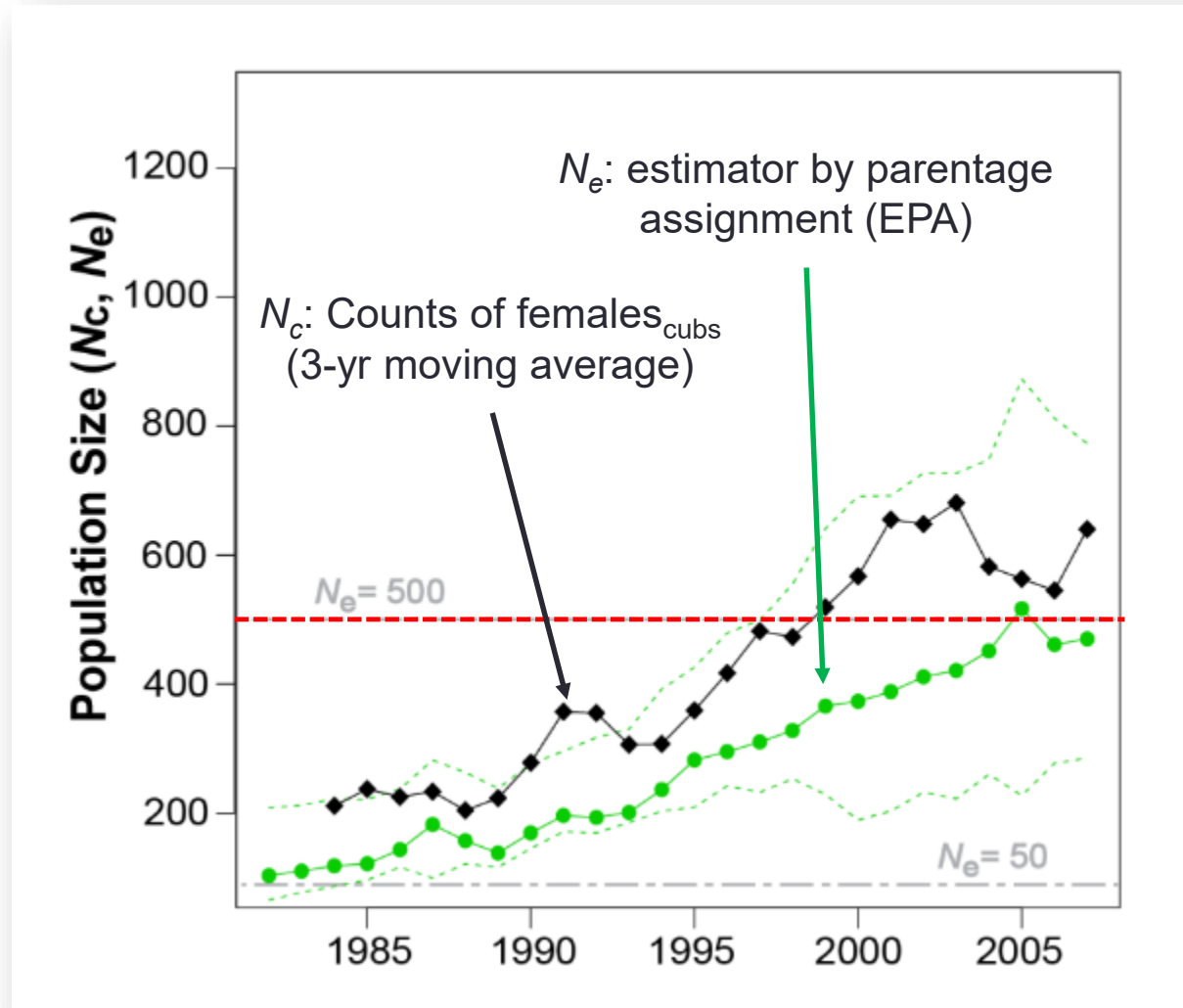




# Genetic connectivity



# Yellowstone effective population size

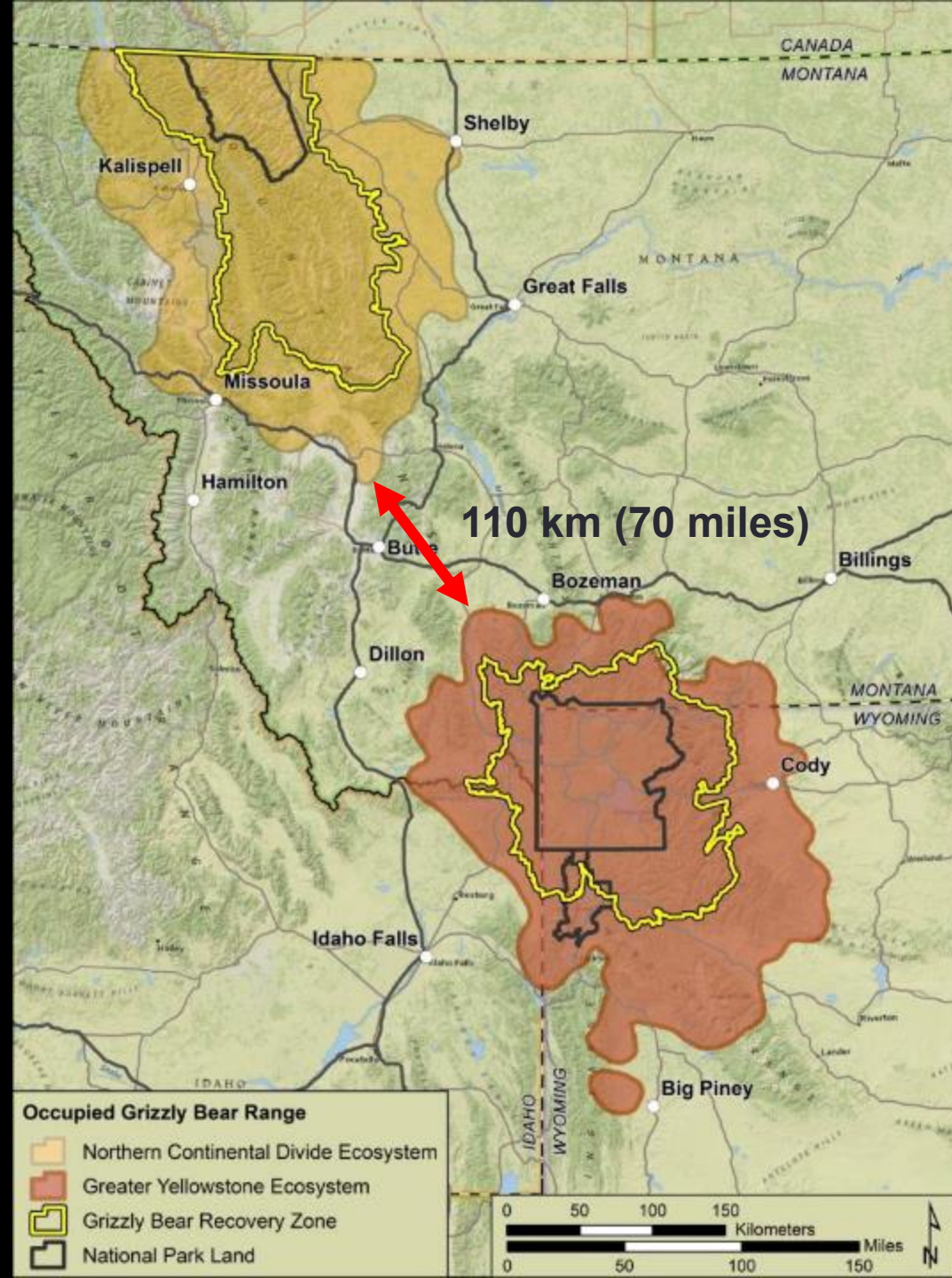




# Occupied Range

Northern Continental Divide  
55,200 km<sup>2</sup> (2004-2014 data)

Greater Yellowstone  
58,314 km<sup>2</sup> (2000-2014 data)



# Genetic connectivity

- Long-term management goal for Montana Fish, Wildlife and Parks - natural movement favored over translocation of bears between ecosystems
- Public interest - genetic connectivity major concern among thousands of public comments about delisting





Study Approach : Model movements based on data from GPS-collared bears

- Sample of research-monitored bears from both ecosystems

Study Approach : Model movements based on data from GPS-collared bears

- Additional bears monitored for conflict management



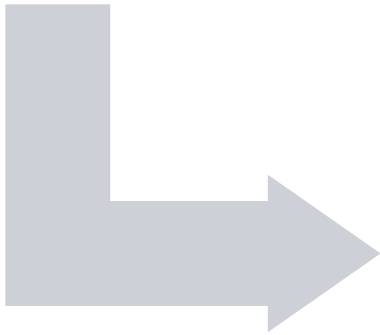
# Data

- GPS data from males  $\geq 2$  years old
  - 124 individuals (199 unique bear-years)
  - 126,000 steps involving movements  $> 100$  m
- Spatial data layers (300-m resolution)
  - Distance to forest edge
  - Natural contagion
  - NDVI (greenness)
  - Distance to rivers and/or streams \*
  - Elevation
  - Ruggedness
  - Primary and/or secondary roads (density or distance) \*
  - Home density

# Analytical approach

Develop step-selection models based on bear movement data

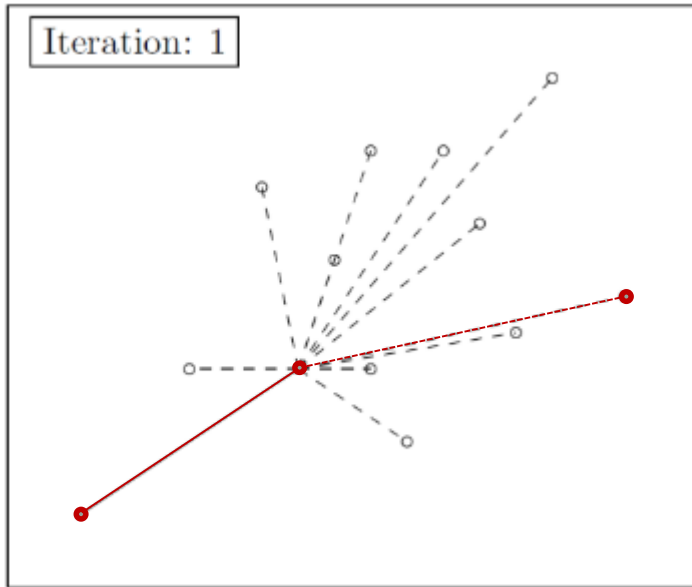
- NCDE model
- GYE model



Apply models using randomized shortest path algorithms

- NCDE paths
- GYE paths
- Intersection paths

# Step-selection functions

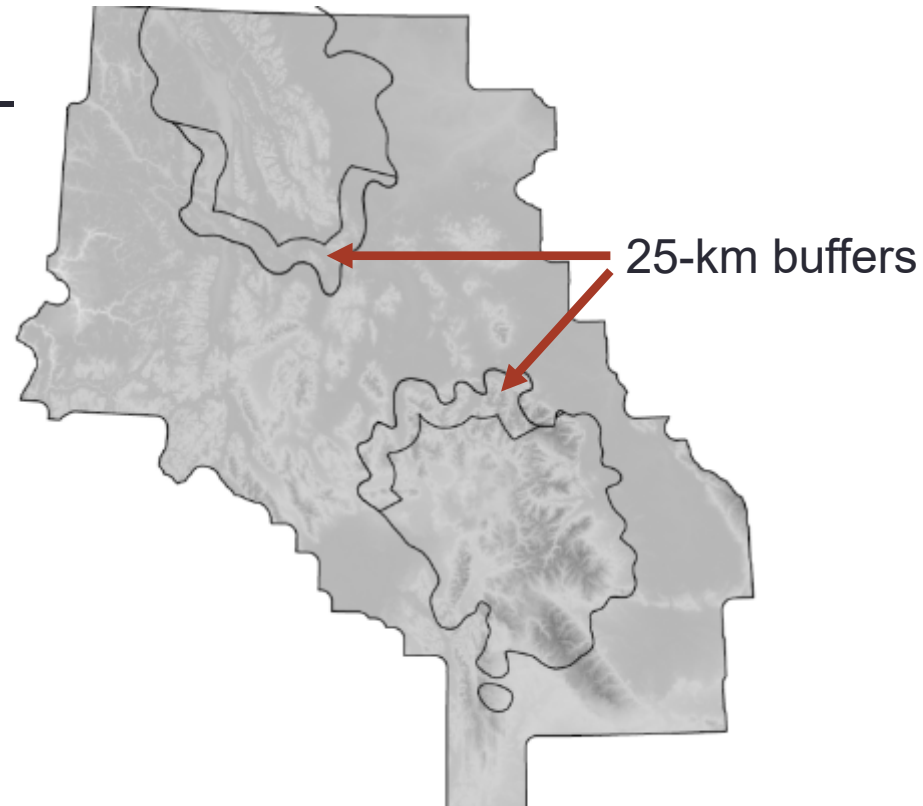


- Iterative process involving turn angles and step-lengths
- Model selection with  $AIC_c$
- 5-fold cross-validation, repeated 100 times  
(Median Spearman rank correlations: NCDE = 0.94, GYE = 0.86)



# Randomized shortest paths (RSP)

- Resistance surface from step-selection model
- 100 random start and end nodes
- Calculate average number of net passages in grid cells
- 3 levels of  $\Theta$  (theta) = trade-off between exploration and optimal exploitation of landscape



# Paths

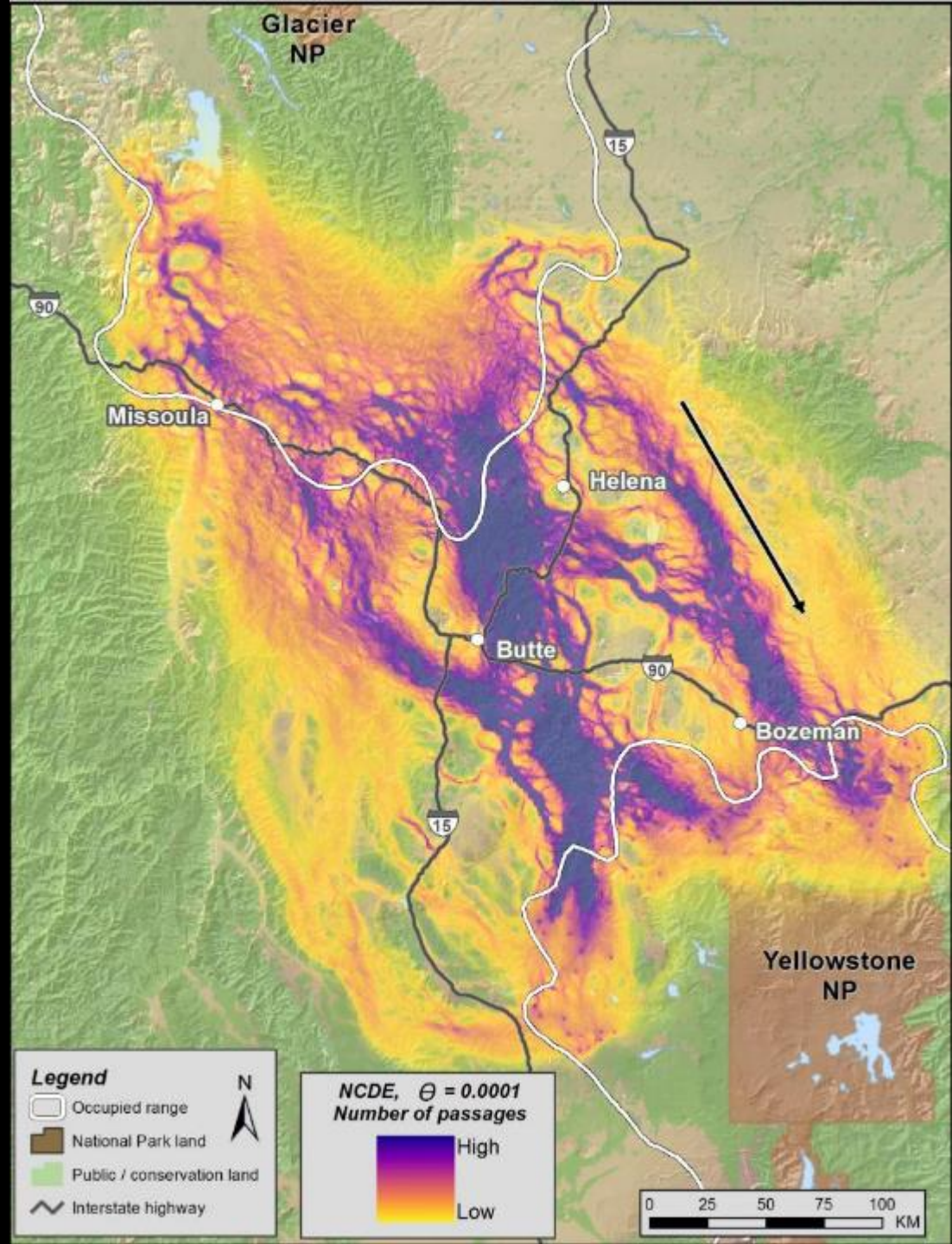


*Photo: Jake Davis*



# Randomized Shortest Paths

Northern Continental Divide  
to  
Yellowstone



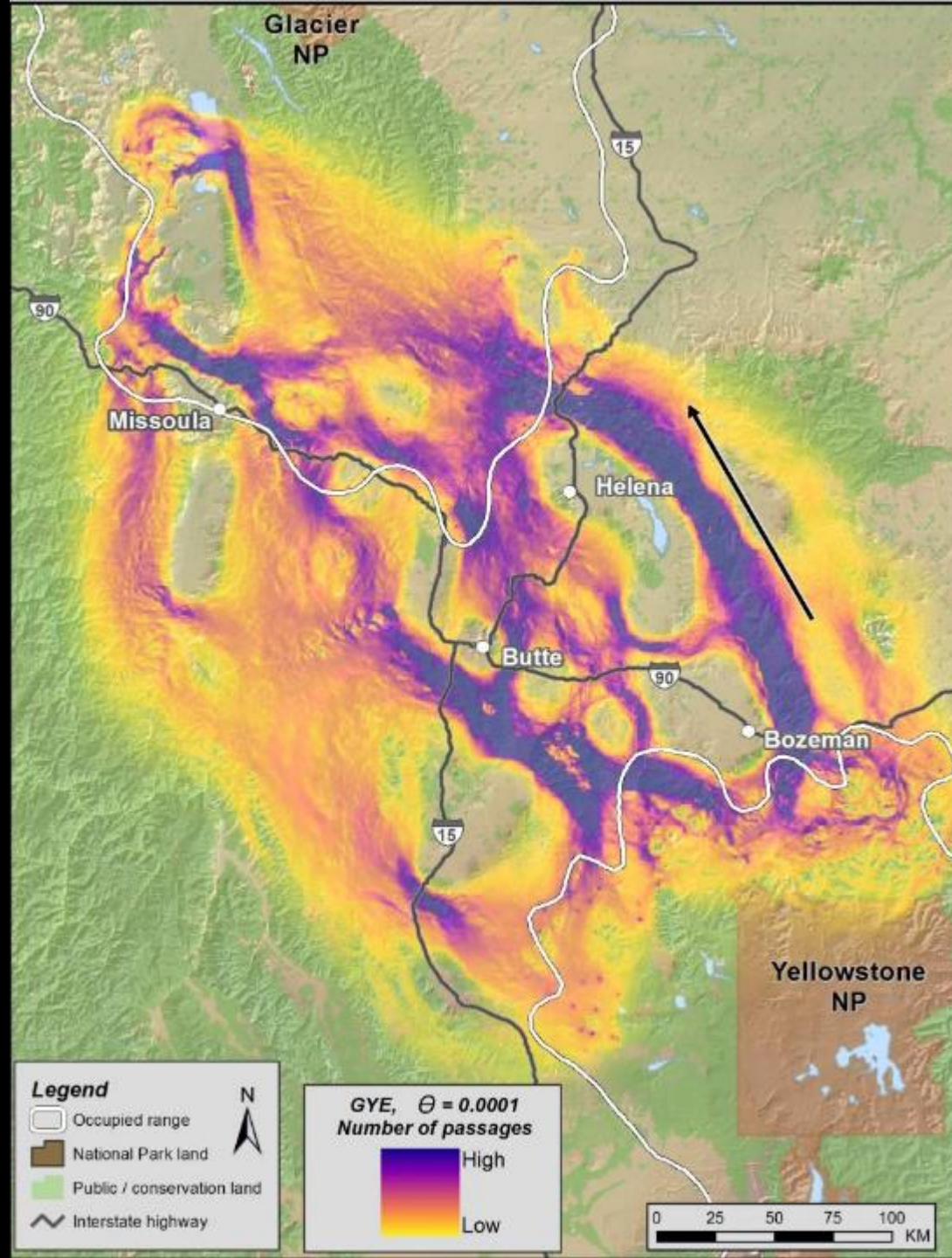


# Randomized Shortest Paths

Yellowstone

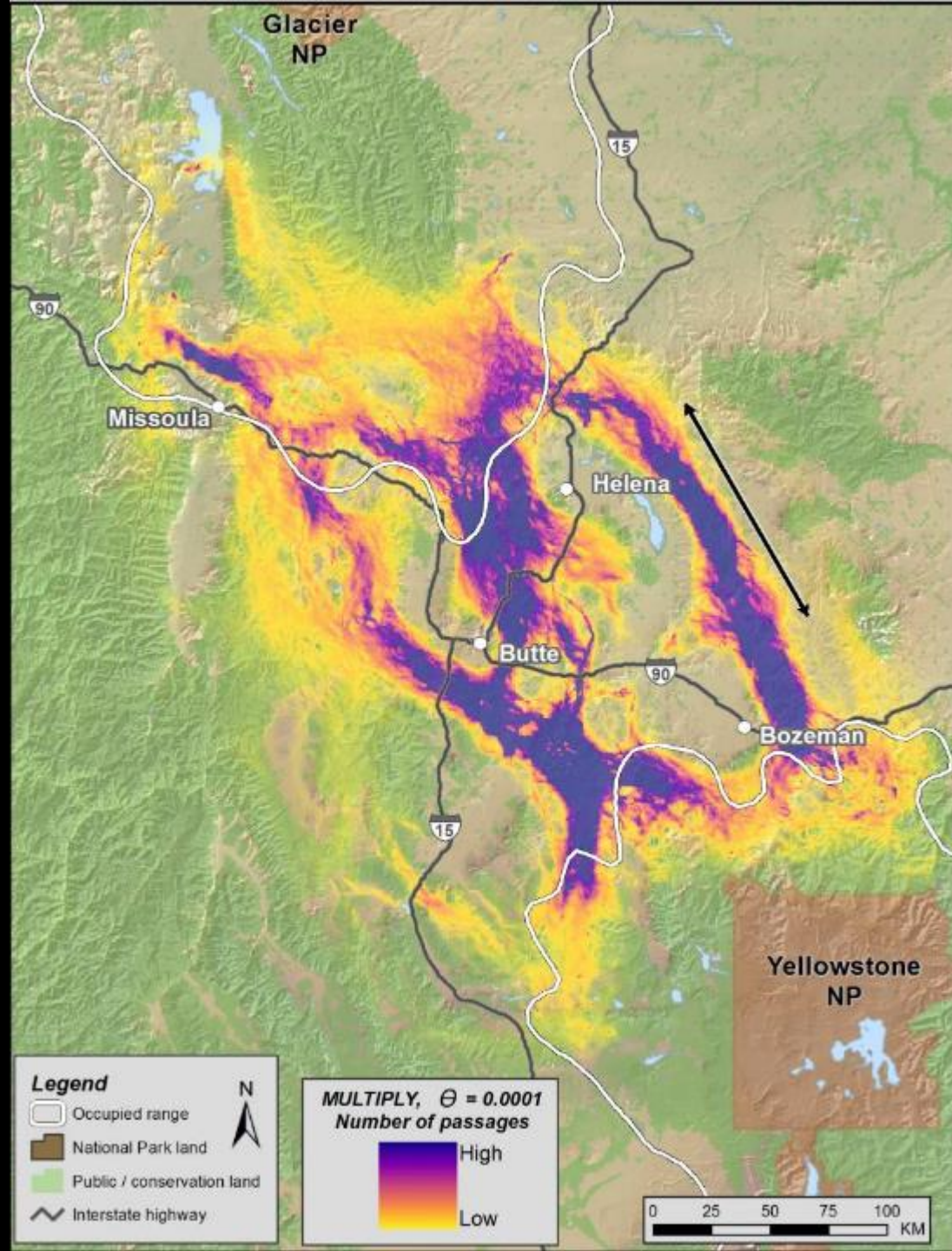
to

Northern Continental Divide



# Randomized Shortest Paths

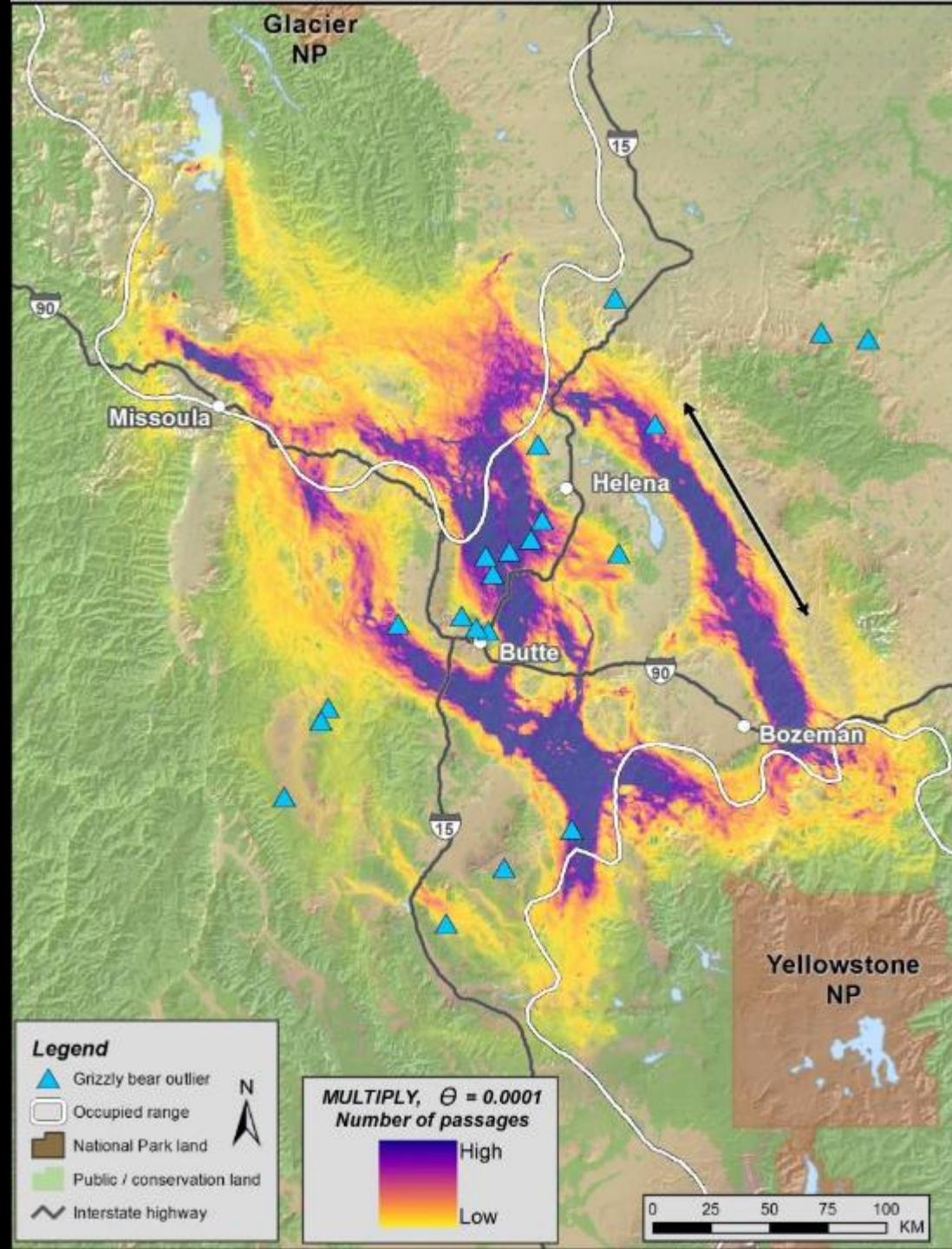
Intersect of paths between  
Northern Continental Divide  
and  
Yellowstone





# Ad-hoc validation

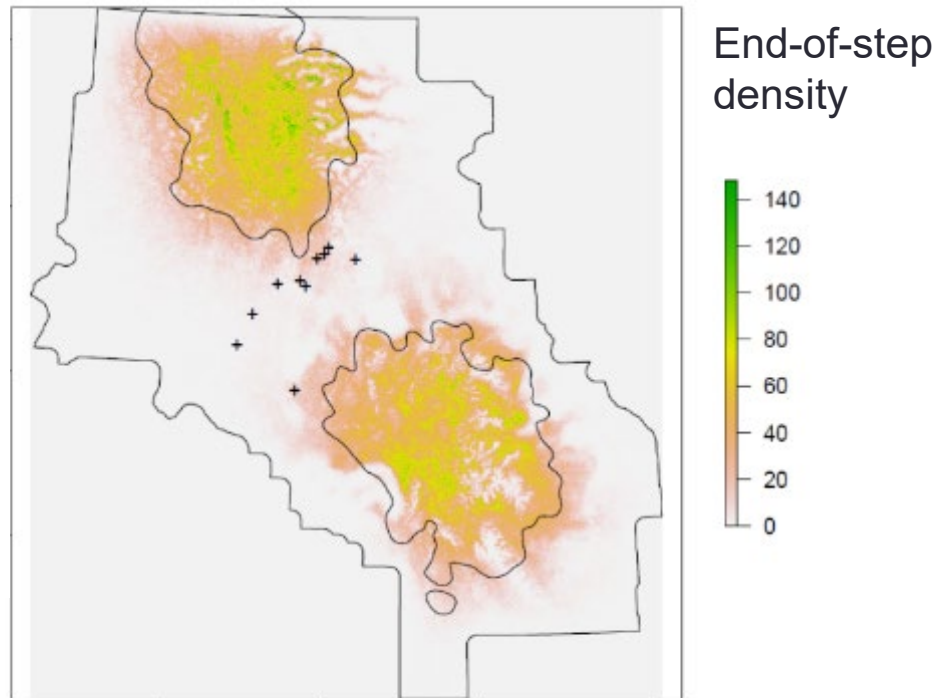
- 21 verified records
- Mortalities, remote camera, tracks, or DNA
- 1998-2017
- 87% in last 4 years
- High correspondence with path predictions:  
quantiles = 0.75 to 0.87





# Rare events

- no successful “immigration event” for 20,000 simulations of correlated random walks



# Informing management

- Target groups: agency managers, NGOs, public
- Identify and prioritize conservation measures
  - Conservation easements and land purchases
  - Mitigation of potential barriers (e.g., highways)
  - Proactive attractant management
  - Education and information programs
- Path layers available online

# Informing management



## Montana Department of Fish, Wildlife & Parks Grizzly Bear Management Goal

“To manage for a recovered grizzly bear population in western Montana and to provide for a continuing expansion of that population into areas that are *biologically suitable* and *socially acceptable*.”



# Conservation on private land

- NCDE Recovery Zone
  - 91% Public land
- GYE Recovery Zone
  - 98% public land
- Connectivity area
  - 49% public land



# Conservation on private land



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## Cheetahs seek refuge on farmland, complicating conservation

By Dana Kobilinsky

Posted on December 26, 2017



A female cheetah uses a high vantage point to look for potential prey. ©Stéphanie Périquet

"Farmers are the future of cheetahs, not their enemy."

Florian Weise, lead author





Paper - Peck et al. 2017. Potential paths for male-mediated gene flow to and from an isolated grizzly bear population

➤ search “Ecosphere 8(10):e01969”

GIS layers - <https://www.sciencebase.gov/catalog/>

➤ search “grizzly bear paths”



REVEALED in NATURE

Photo: Jake Davis